3: Transfer Functions, Parameters, and Equivalent Circuits of Linear Amplifiers: PART B

ECE 3200 Electronics II
updated 24 February 2021

Reference

1. S. Sedra and K. C. Smith, Microelectronic Circuits, 7th ed., Oxford University Press, 2015.

Objectives (cont'd)

3. To measure via simulation the dynamic open circuit voltage transfer function and the dynamic short circuit current transfer function of a simple direct coupled linear amplifier.

4. To develop an awareness of the necessity of ensuring that an amplifier is operating in its linear region when its "linear" parameters are being measured.

Procedures

You will apply a sine wave, a triangular wave, and a square wave to the amplifier of LAB 3 PART A. Use LTspice® SINE and PULSE functions to generate these waveforms. Be sure to use a small "Maximum Timestep" in the simulation, e.g. 10µs, otherwise the square wave will not look "square." You can add a DC voltage source in series with the signal source to provide a DC offset if needed.

Use your measured component values in your simulations.

1. DYNAMIC OPEN CIRCUIT VOLTAGE TRANSFER FUNCTION MEASUREMENT

   Note that R_S is still 0 and R_L is still very large.

   For each of the following waveforms:
   Plot input voltage $v_I(t)$ and output voltage $v_R(t)$.
   Plot output voltage $v_R(t)$ vs $v_I(t)$ in an "XY" plot
   This is the dynamic open circuit voltage transfer function at 40Hz.

   Determine (as possible) the gain in the linear region, offset voltage, and saturation voltages in each case:

   a. Sine wave: Set $v_I(t) = V_I + V_{im}\sin(2\,\pi\,f\,t)$ where V_I **produces symmetrical** ≈20% "clipping" of both peaks of v_R and f = 40 Hz. These functions are available when you right click on a voltage source and select "Advanced" options:
   SINE(0.1 1 40)

   b. Triangular wave: PULSE(1 -1 0 12.5ms 12.5ms 0 25ms 0). Again, adjust DC input to produce symmetrical clipping.

c. Square wave: PULSE(-1 1 0 1fs 1fs 12.5ms 25ms 0).). Again, adjust DC input to produce symmetrical clipping. Something might be missing in the XY plot… what is it?

Compare each case to the static (DC) open circuit voltage transfer function generated in LAB 4 PART A. Are they the same? Why or why not?

2. DYNAMIC SHORT CIRCUIT CURRENT TRANSFER FUNCTION

Change R_L to a short circuit (use 0 ohms) and plot $i_L(t)$ vs $i_I(t)$. Use a SINE source at f = 40 Hz for $v_S(t)$. Ensure that i_L varies from well into negative saturation to well into positive saturation. This is the dynamic short circuit transfer function at 40Hz.

Be sure to find the

a. output offset current (the output current when the input current is zero and $R_L = 0$);

b. current gain (in the linear region of course);

c. range of linear operation; and the

d. saturation currents.

Exercises

As always, use figures, graphs, circuit diagrams, theoretical analysis, etc., to support your responses. Repeat your simulation at home as needed.

1. Using results from procedure 1, identify what if any effects f, V_{im}, and the shape of $v_i(t)$ have on the shape of the transfer function.
2. Explain the resulting output waveforms for each waveform case of procedure 1 by using the graph of the dynamic transfer function simulated in procedure 1.
3. What property of the transfer function is readily apparent from the data in procedure 1 parts a and b but is disguised in procedure 1 part c?

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